Status of Physics Analyses in ALEPH

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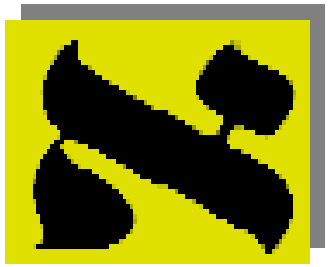
on behalf of the ALEPH Collaboration

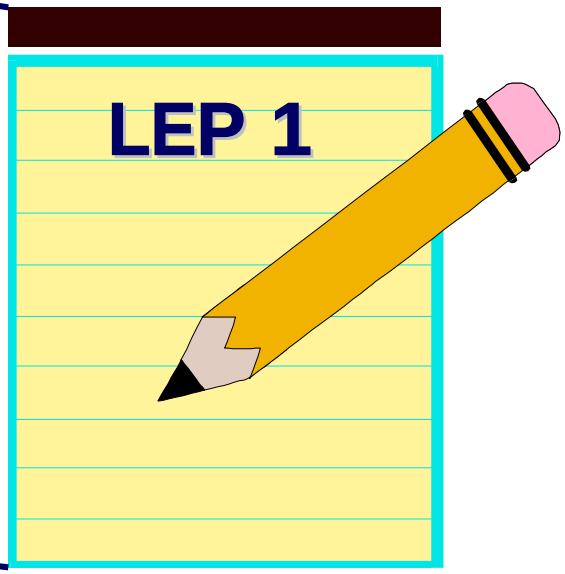


LEP Physics Jamboree, July 10 2001,

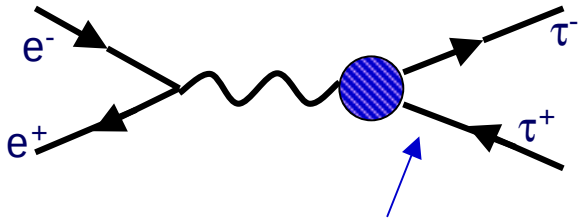
Status of the Detector

Outlook LEP1:

- Tau Physics
- Heavy Flavour Physics
- QCD



Weak Dipole Moments of the τ Lepton



- Aim : Study the Lorentz structure of this coupling

$$ie\left(\mathrm{v}_\tau\gamma^\mu - \mathrm{a}_\tau\gamma_5\gamma^\mu + i\frac{\mu_\tau}{2m_\tau}\sigma^{\mu\nu}q_\nu + \frac{d_\tau}{2m_\tau}\gamma_5\sigma^{\mu\nu}q_\nu\right)$$

?

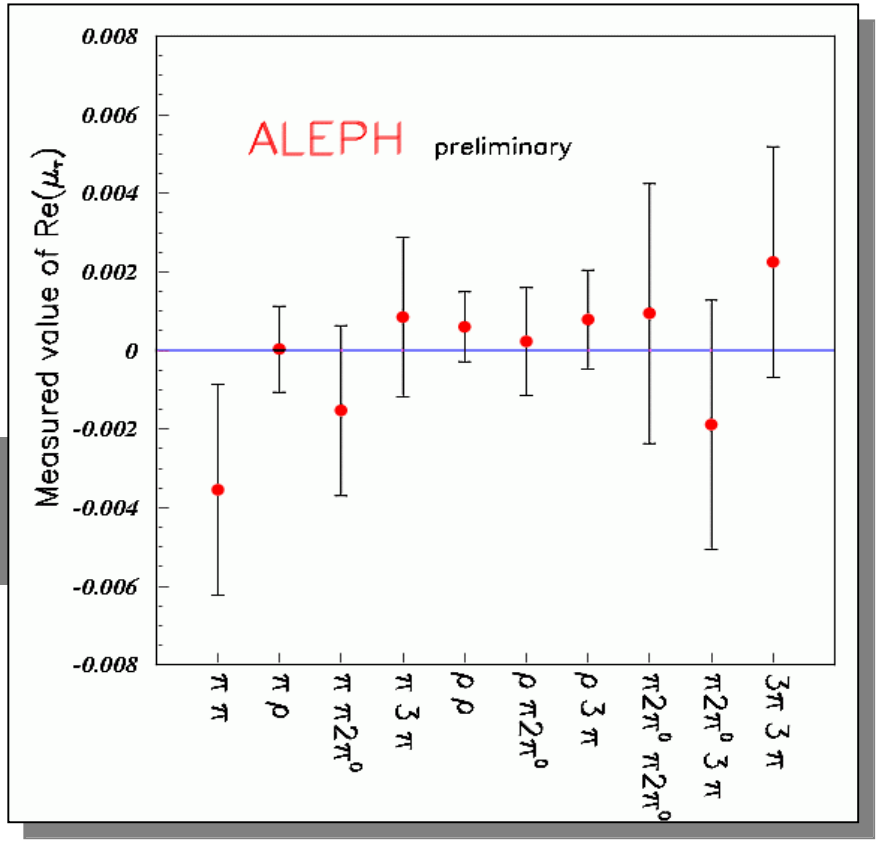
- Method : Likelihood fit (simultaneous for all couplings) to fully differential cross section for

$$\frac{d\sigma}{d\cos\theta\, d^n X}\left(e^+e^- \to \tau^+\tau^- \to X\right)$$

Production

decay : π, ρ, $a_1 \to \pi 2\pi^0$ (3π)

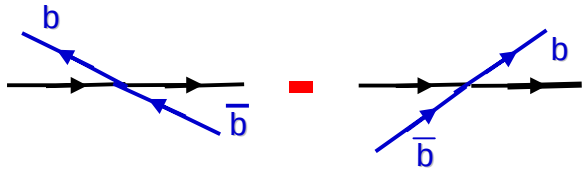
- Data : 155 pb-1 (1990-1995) ⇒ 39k events



95% CL upper limits	|Re()|	|Im()|
μ_τ	1.05 x 10^{-3}	2.22 x 10^{-3}
d_τ [e cm]	5.42 x 10^{-18}	11.93 x 10^{-18}

A_{FB}^{b} using Jet Charge

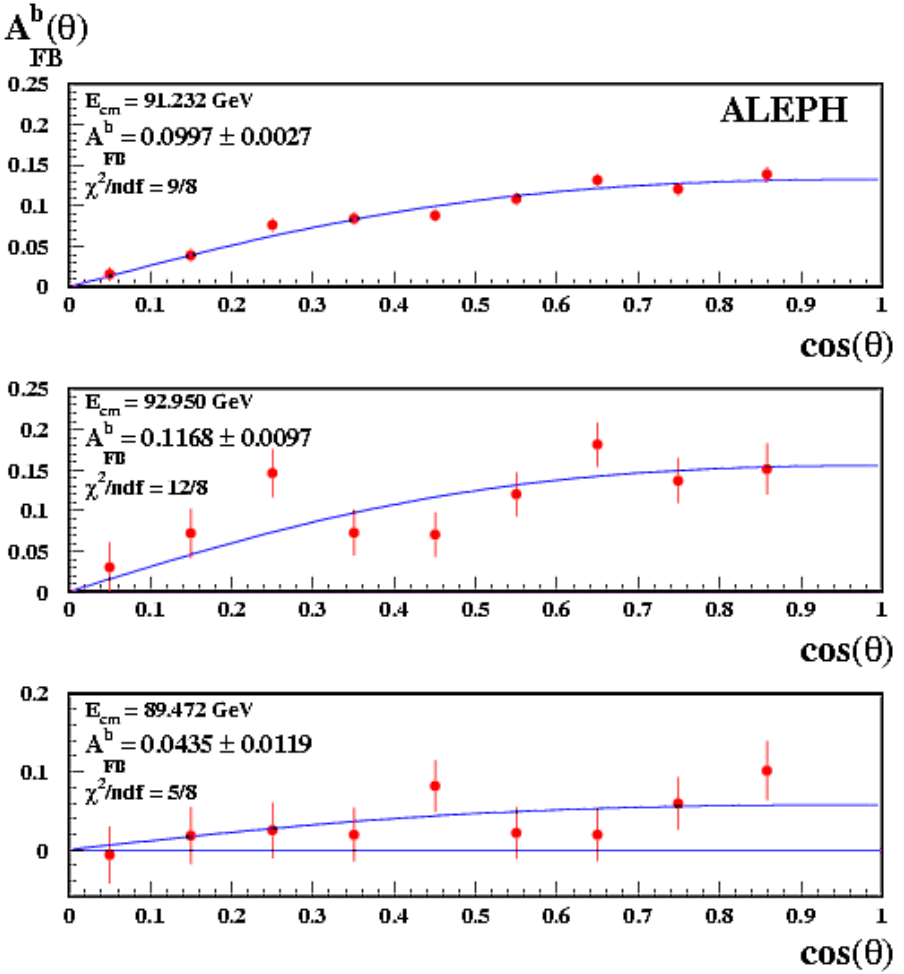
- Aim :Measure

$\sigma_{tot}^{b} A_{FB}^{b} =$ 

$\Rightarrow \sin^2\theta_W$

- Method : inclusive measurement
  - b-tag via NN (30% more stat)
  - Improved jet charge tag includes
    - fast Kaon tagging
    - primary+secondary vertex charge
  - lower systematics because
    - lower mistag rate
    - purities from double tag method

- Data : 1991-1995
  - 4 million evts, 670k b-tagged evts

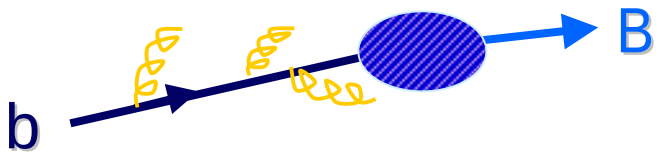


$A_{FB}^{0,b} = 0.1009 \pm 0.0027 \pm 0.0012$

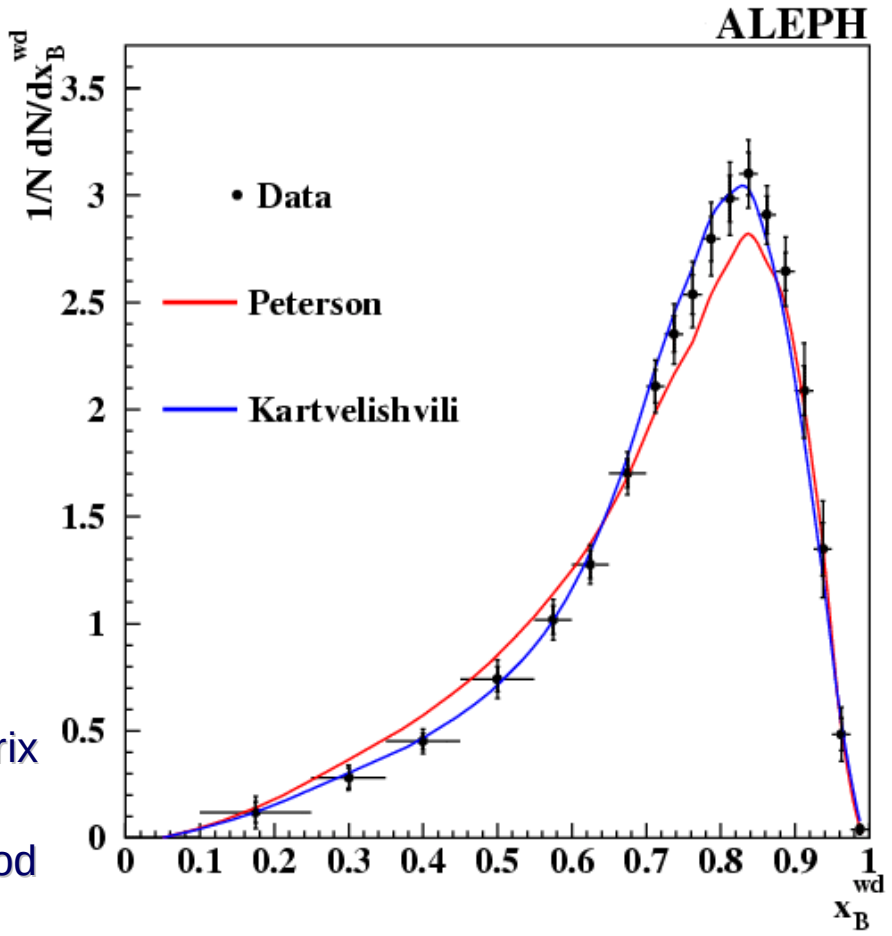
$\sin^2\theta_W = 0.23193 \pm 0.00056$

FINAL, CERN EP/2001-047

b Quark Fragmentation Function



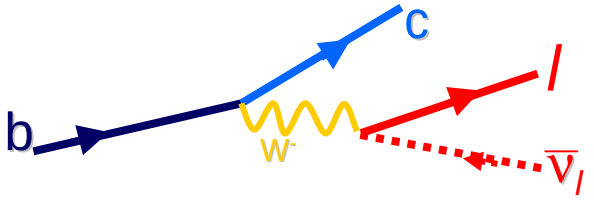
- Aim : measure the spectrum of
  $x_E = E_B / E_{beam}$
- Method : semi-exclusive reconstruction
  - $B \rightarrow D^{(*)} / \nu$
  - 5 channels for $D^{(*)}$ decays
  - E_ν from missing energy in hemisphere
  - Unfold raw distribution with resolution matrix from MC
  - avoid model dependence by iterative method
- Data : 1991 - 1995
  - ≈ 4 million hadr. Z decays
  - ≈ 3400 B^0 and $B^\pm$ candidates
- Accepted by Phys.Lett.B



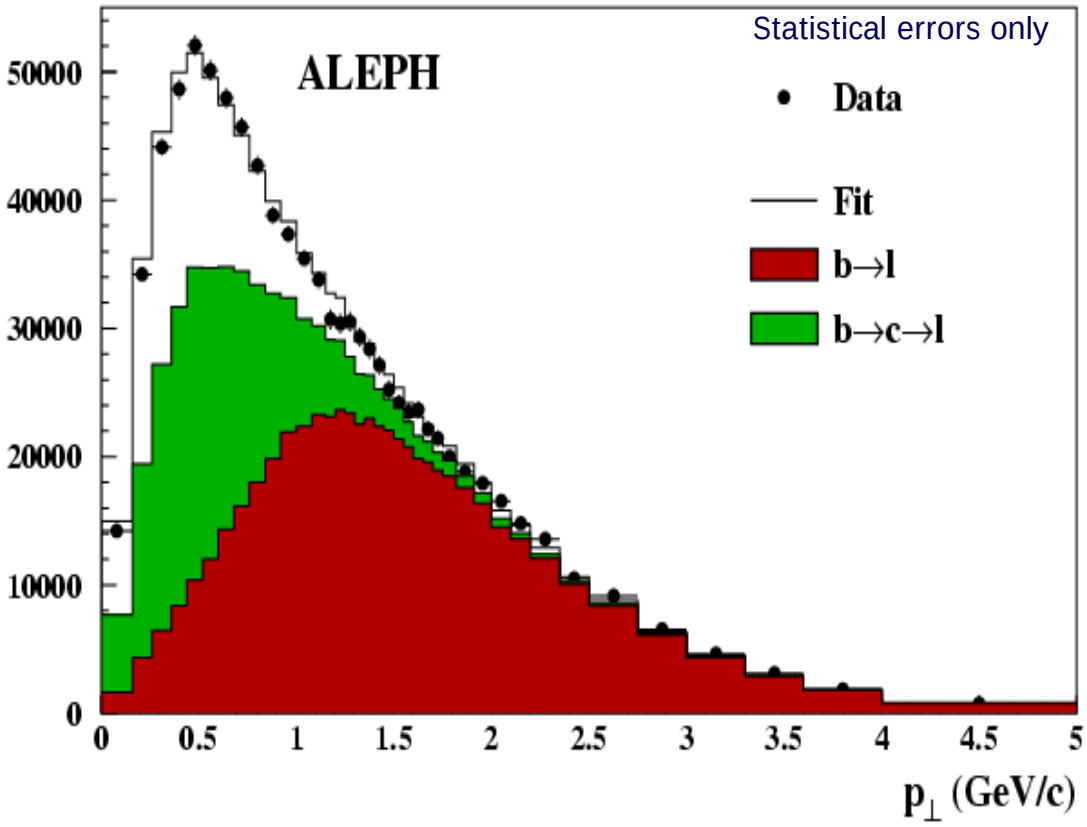
$\langle x_B^{wd} \rangle = 0.716 \pm 0.006 \pm 0.006$

SLD : $\langle x_B^{wd} \rangle = 0.710 \pm 0.003 \pm 0.005 \pm 0.004$

Inclusive b semileptonic BR



- Aim : measure the BRs
  - BR(b → X / ν)
  - BR(b → c → X / ν)
- Method : 2 analyses
  - b-tag OR high $p_\perp$ lepton OR charge+impact parameter tag
  - search for lepton (e, μ) in opposite hemisphere
    - improved dE/dx (TPC pads)
  - A) fit $p_\perp$ spectrum
  - B) measure charge correlation
- Data : 1991 - 1995
  - combine results a) and b)



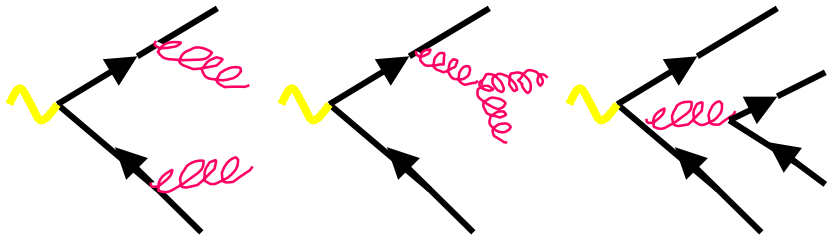
$$BR\ (b \to X\ l\ \nu) = 0.1070 \pm 0.0010 \pm 0.0024 \pm 0.0025_{model}$$

$$BR\ (b \to c \to X\ l\ \nu) = 0.0818 \pm 0.0015 \pm 0.0023\ ^{+0.0008}_{-0.0012\ model}$$

Sending to journal

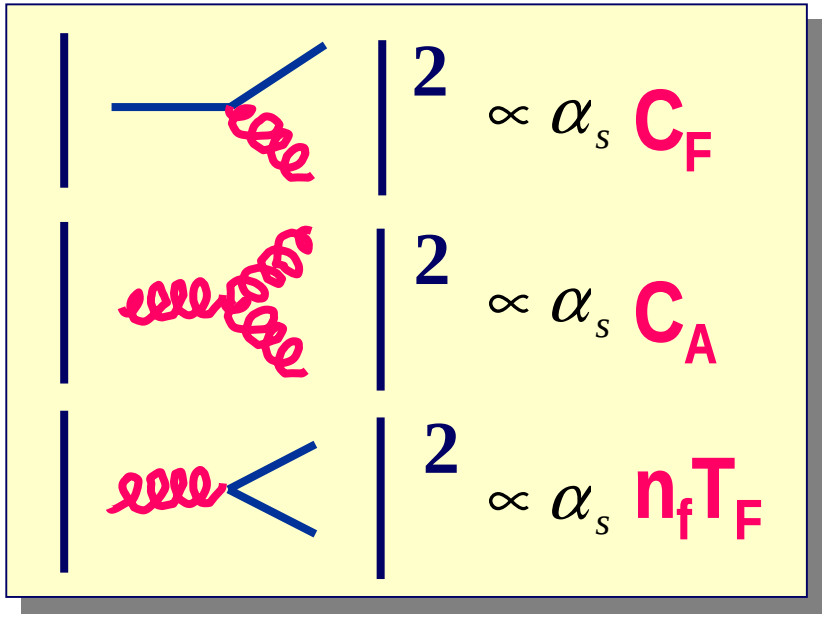
α_s and QCD Colour factors

- Aim : measure simultaneously the strong coupling and the QCD colour factors using 4-jet evts



- Method : Fit NLO predictions to 4-jet observables
  - R_4 (y_{cut})
  - four angular correlations in 4-jet events
    - Bengtsson-Zerwas angle, ...

- Data : 1994 - 1995
  - ≈ 2.5 million hadr. Z decays
  - ≈ 163k 4-jet evts (y_{cut} = 0.008)



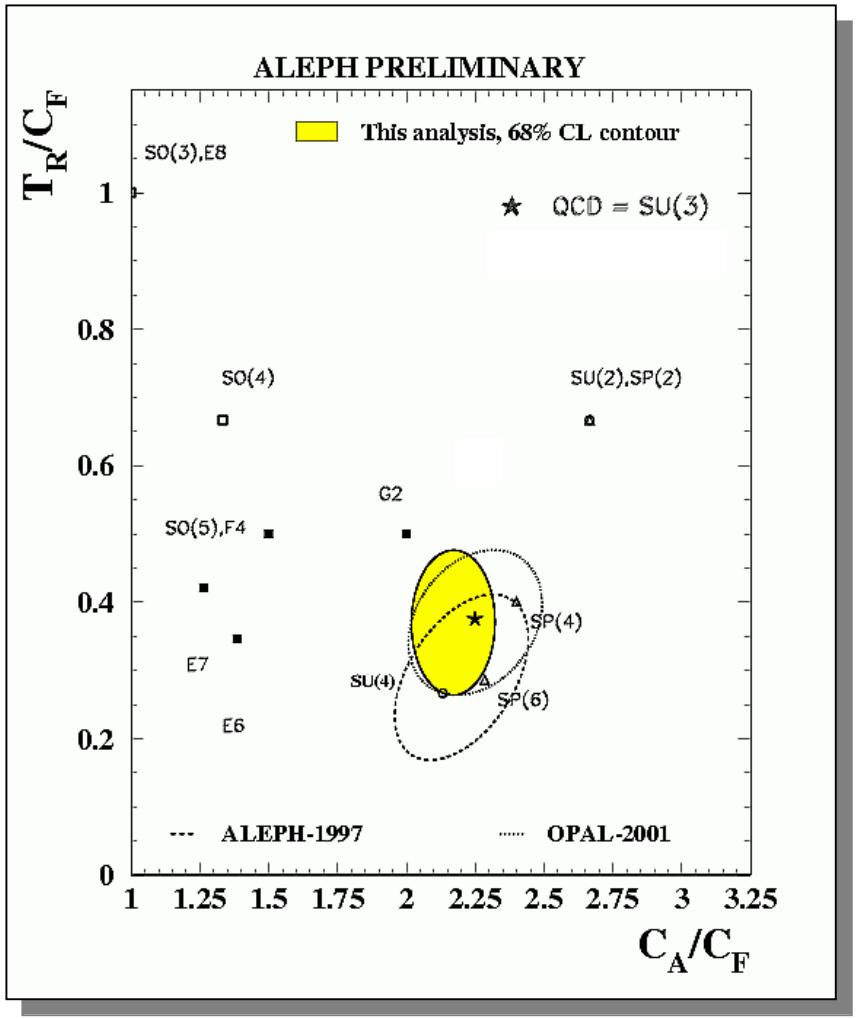
QCD : SU(3)
C_F=4/3, C_A=3, T_F=1/2

$\alpha_s(M_Z) = 0.119 \pm 0.006 \pm 0.022$

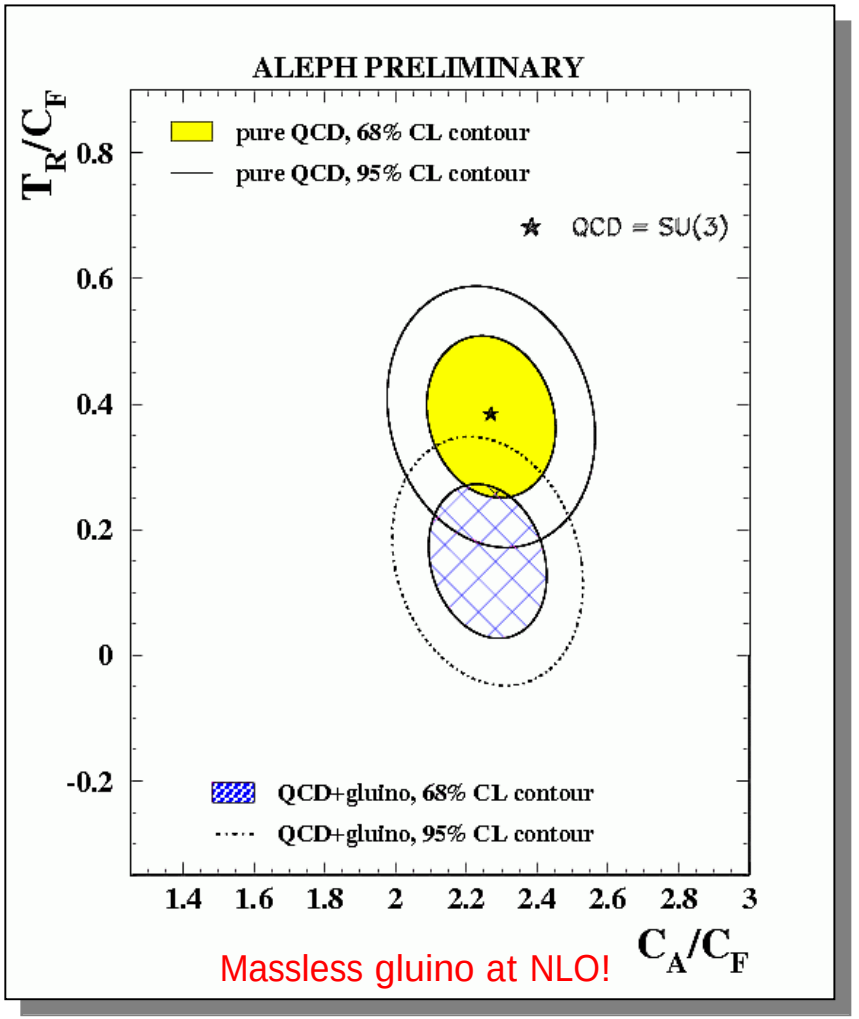
$C_A = 2.93 \pm 0.14 \pm 0.49$

$C_F = 1.35 \pm 0.07 \pm 0.22$

α_s and QCD Colour factors...



Using all variables

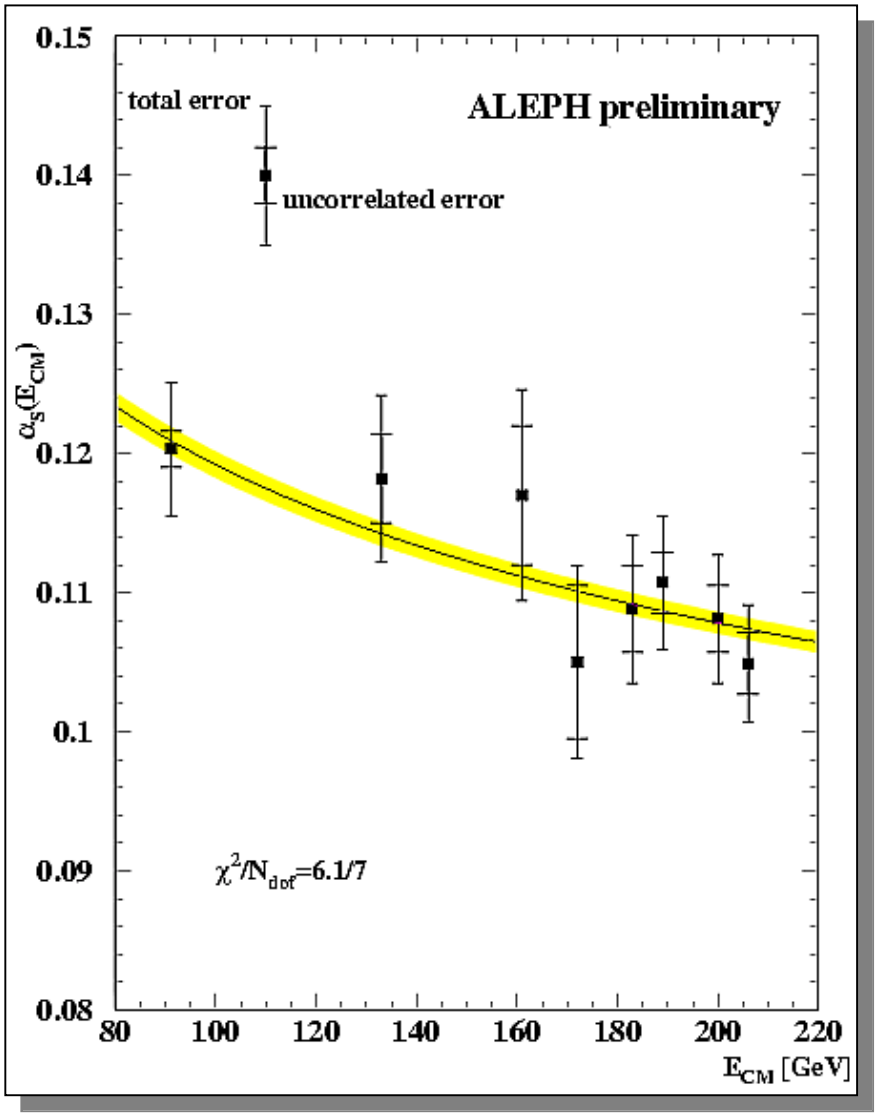


Using only angular correlations + assuming standard hadronization corrections!

α_s from Event Shapes

$$\frac{1}{\sigma_{had}}\frac{d\sigma}{dy} = \alpha_s A(y) + \alpha_s^2 B(y) + f(\alpha_s^n \ln^m y)$$

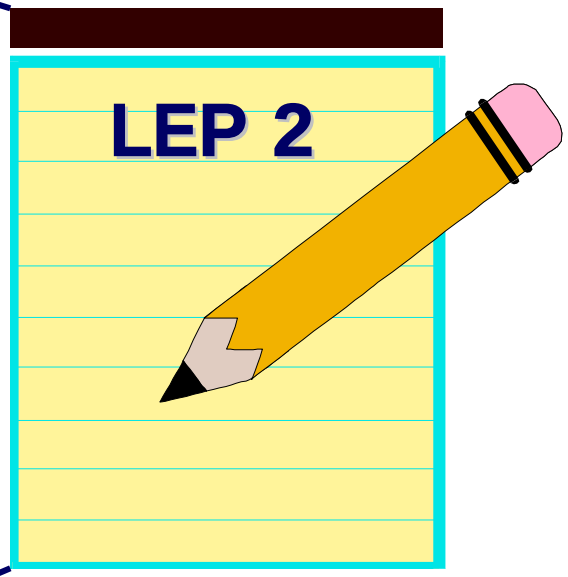
- Aim : measure α_s from fit of NLO+resummed QCD predictions to event shape distributions
- Method : from hadronic Z decays
  - Thrust, -lny_3, M_h, C_{par}, B_{tot}, B_w
  - at LEP1 **and** LEP2
  - hadronization corrections from MC
  - consistent treatment of systematic errors at all energies
- Data : combined fit to 91 - 207 GeV



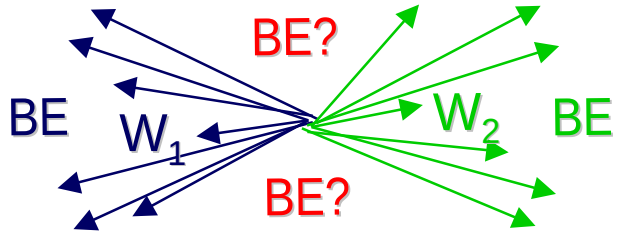
$\alpha_s(M_Z) = 0.1203 \pm 0.001 \pm 0.0013 \pm 0.0046_{theo}$

Outlook LEP2:

- WW (FSI)
- Exotics :
  - anomalous couplings
  - single top
- “Standard exotics”:
  - SUSY
  - Higgs



Bose-Einstein Correlations in WW events



- Aim : look for BE correlations between pions from different Ws

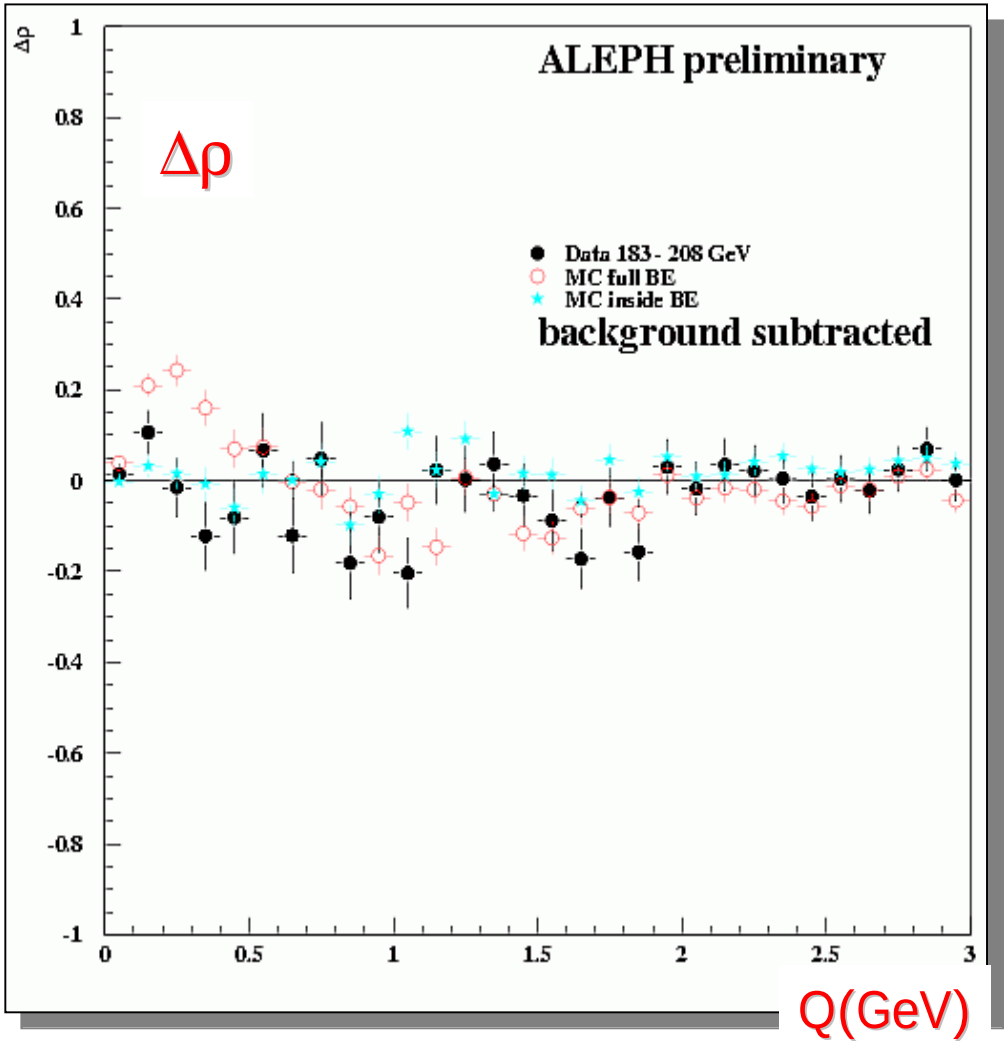
- Method : measure the observable

$$\Delta\rho = \left(Q^{hadr} - Q^{mixed}\right)_{DATA\ -\ Bkgr} - \left(Q^{hadr} - Q^{mixed}\right)_{MC,\ no\ BE}$$

$$Q = \sqrt{\Delta p^2 - \Delta E^2}$$

  - mixed hadronic parts of different semi-leptonic evts

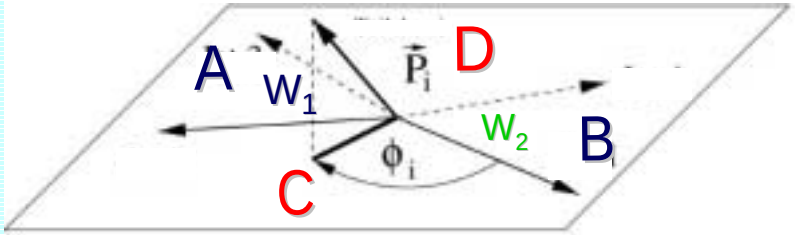
- Data : 183 - 208 GeV



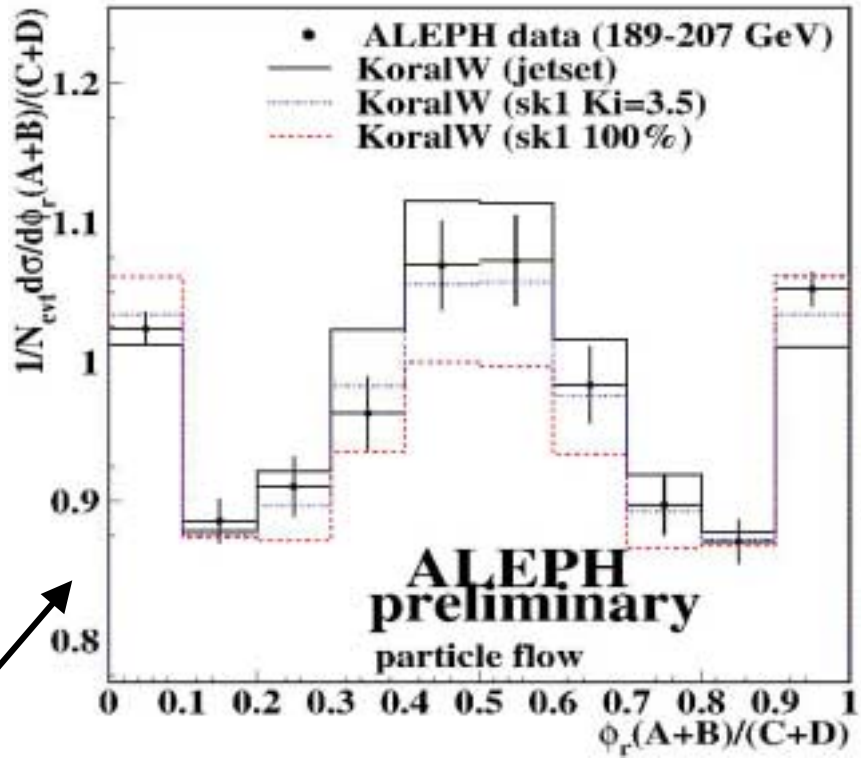
Confirms our previous results:

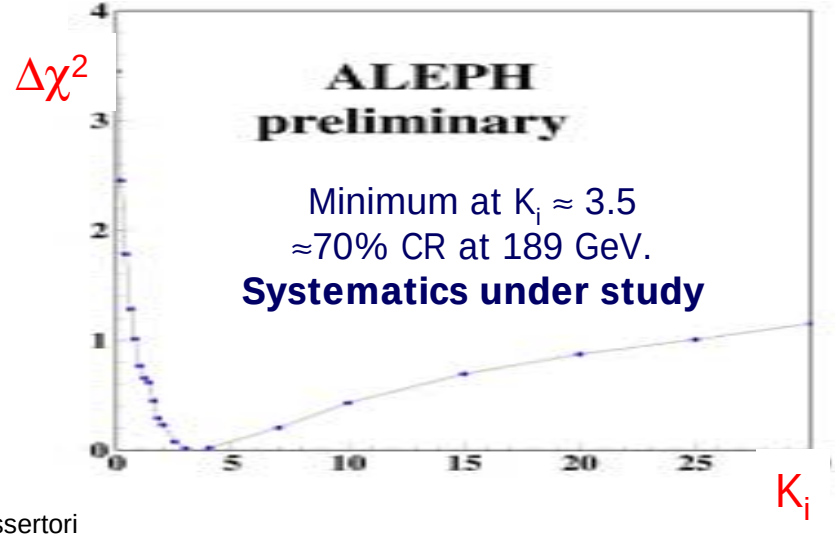
BE correlations between pions from different Ws are disfavoured

Particle Flow in WW events

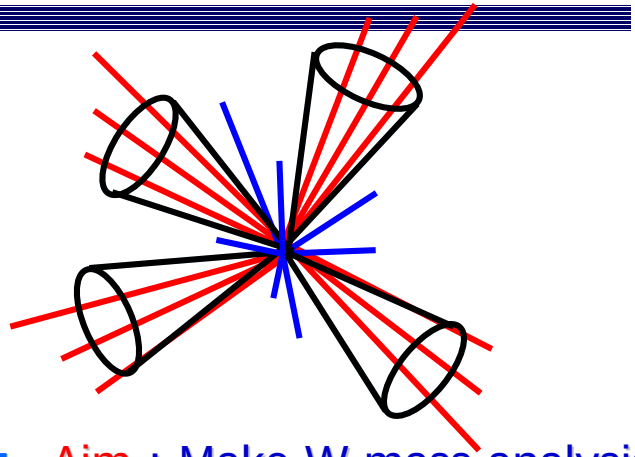


- Aim : look for colour reconnection effects in fully hadronic WW evts
- Method : apply the same selection as for W mass analysis
  - project chg+neutral particles into planes between jets from Ws
  - compute the ratio of particle flow in different interjet regions
  - compare to predictions of different MC models
  - check SKI for different K_i values
- Data : 189 - 207 GeV

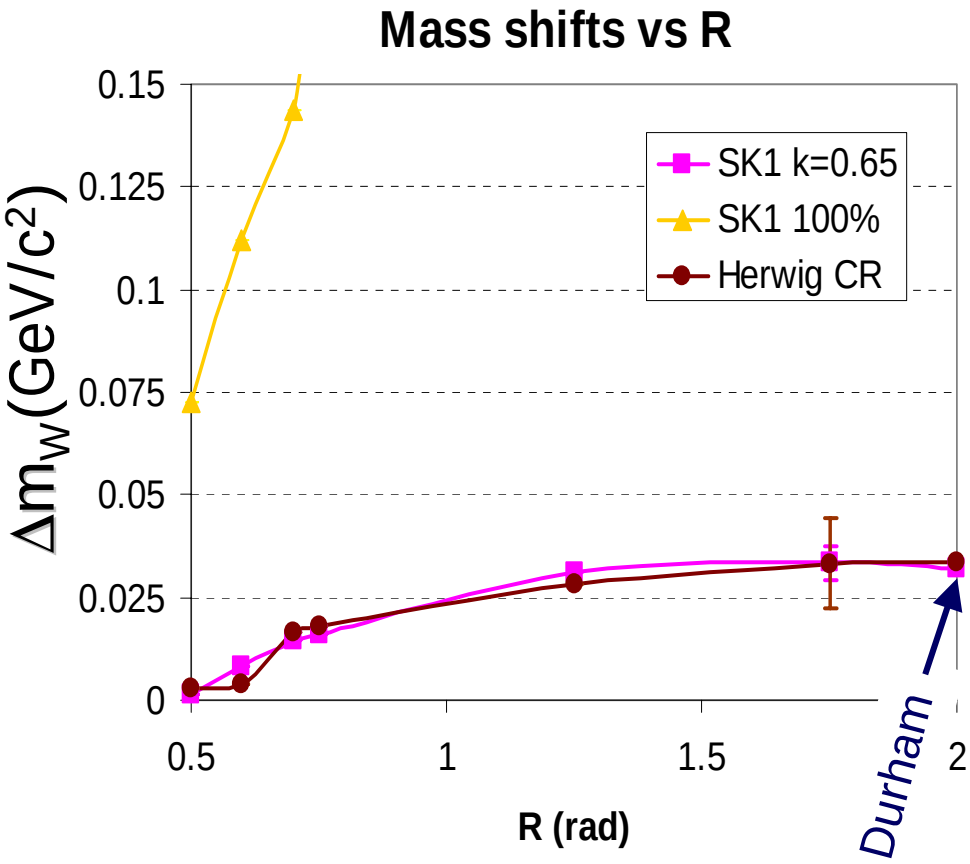




Reduction in FSI uncertainty on M_W?

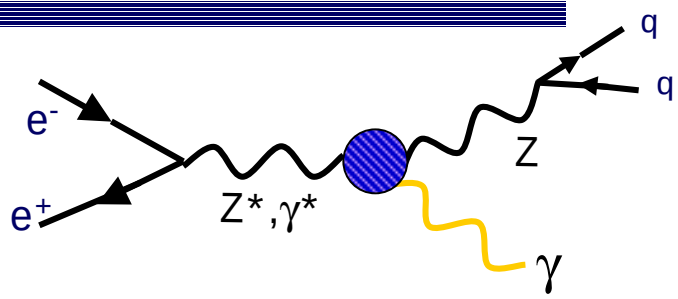


- Aim : Make W mass analysis in fully hadronic channel more robust w.r.t. colour reconnection effects
- Method :
  - a) apply cone jet algorithm in order to recompute jet directions
    - study dependence on cone size
  - b) cut out particles which
    - lie in interjet region
    - are soft

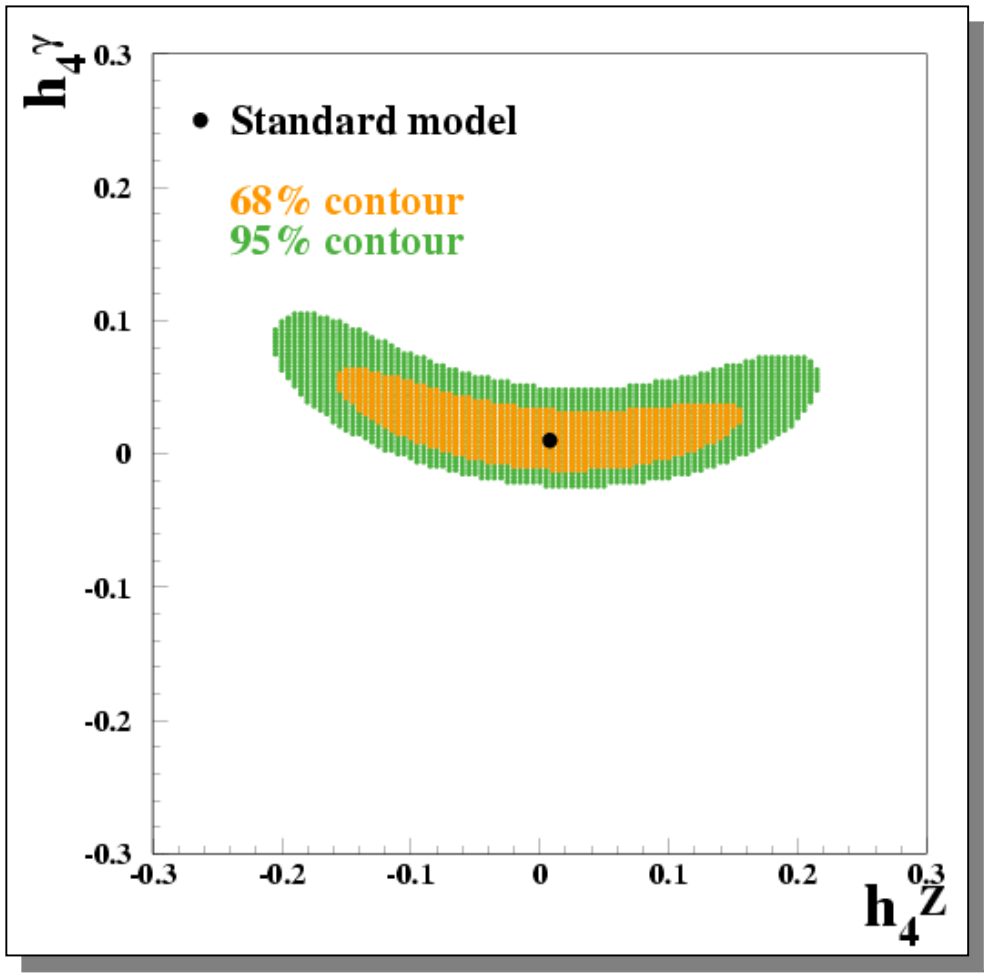


e.g. expected for R=0.75 **reduction by a factor of 2** in Δm_W, with 13% increase in statistical uncertainty

Anomalous Neutral Couplings



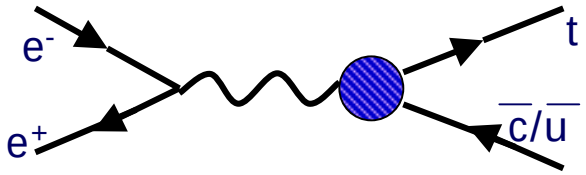
- Aim : look for anomalous contr.
  - in SM forbidden at tree level
  - model them by anomalous vertex contributions $h^{\gamma,Z}_{1,..,4}$
- Method : same topology as radiative returns
  - 2 jets + isolated photon
  - measure cross section, cos (θ_γ), angle(γ-jets)
  - likelihood including anomalous couplings



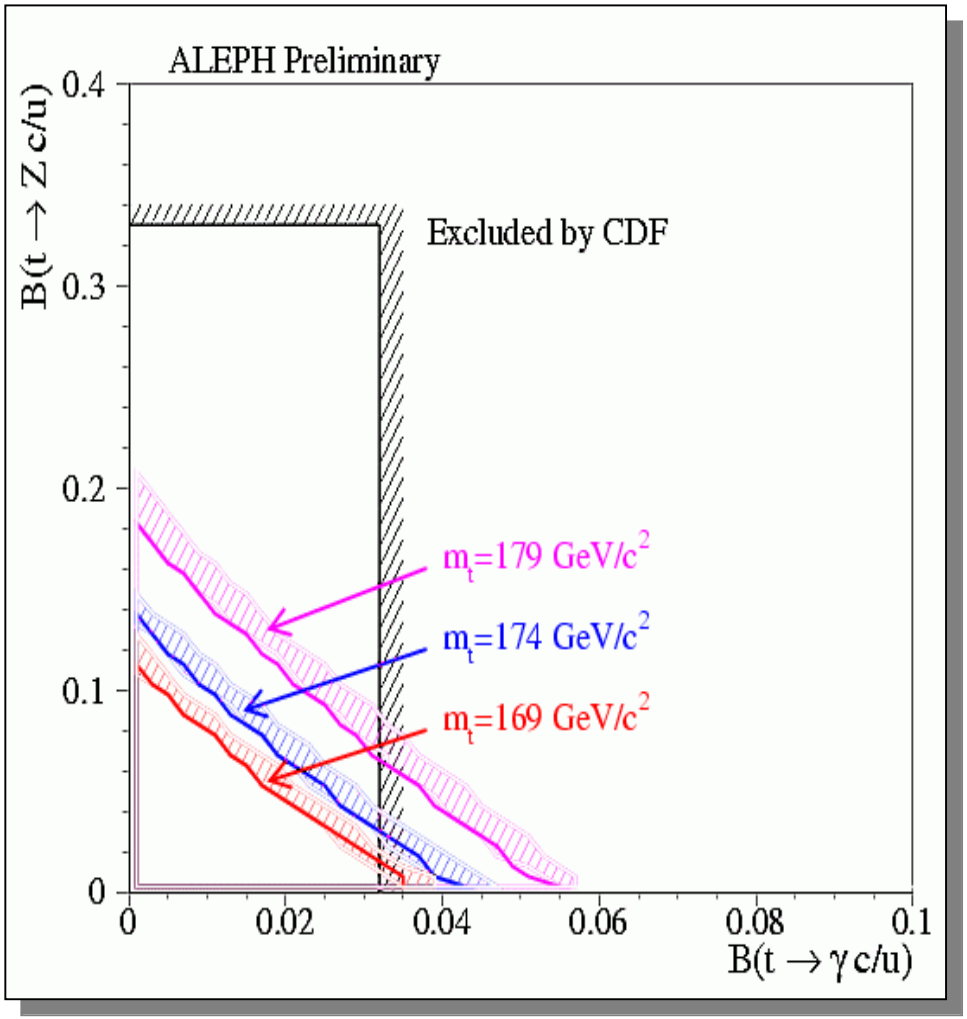
- Data : 189-207 GeV , >600 pb^{-1}

no deviation from SM observed

Single Top Production

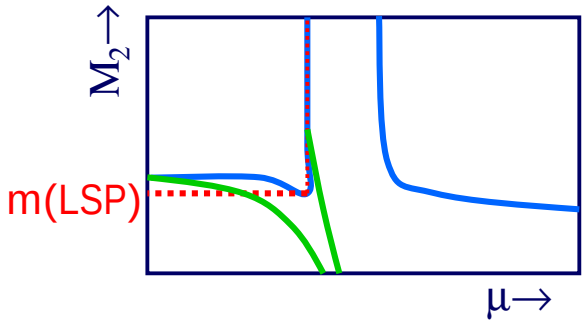


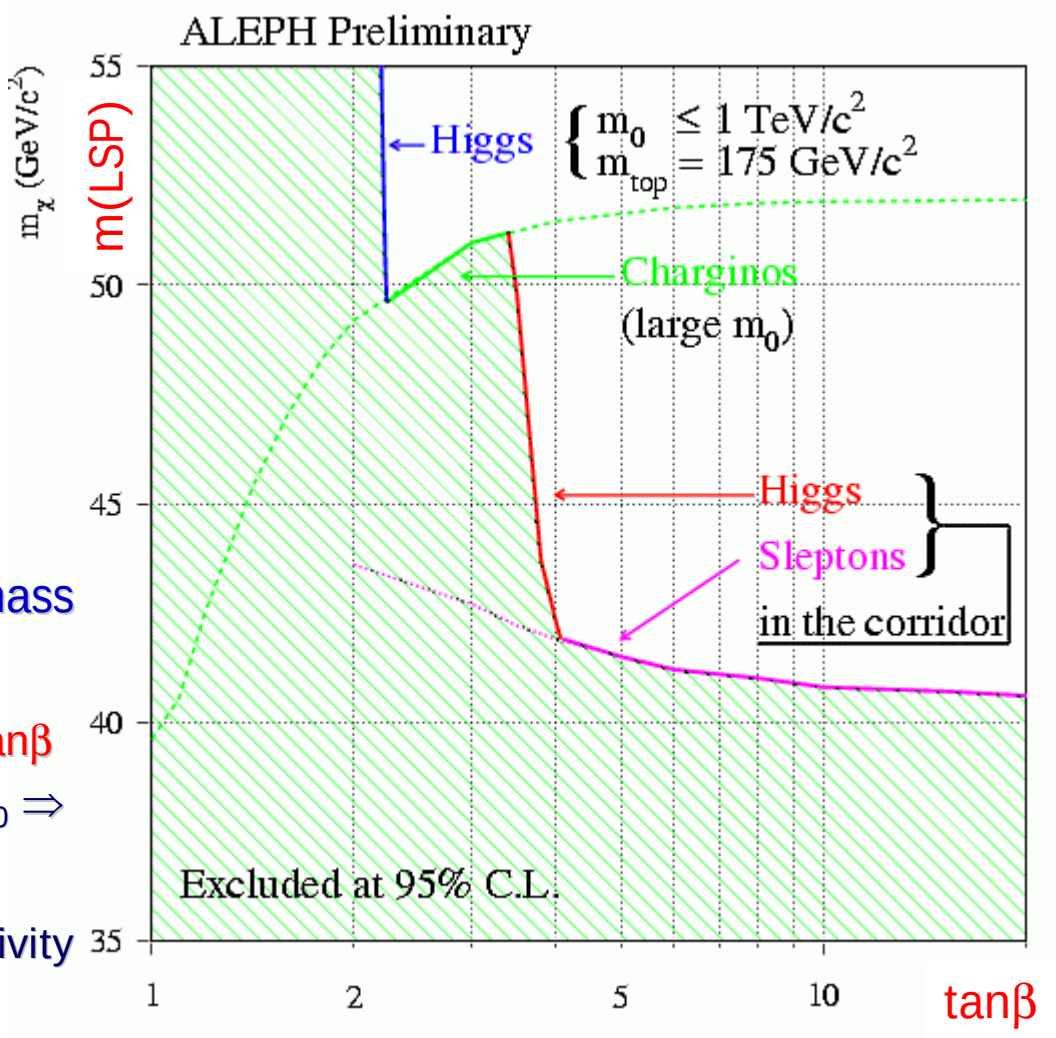
- Aim : look for FCNC
  - in SM only via loops $\sigma<10^{-9}$ fb
  - model FCNC by anomalous vertex contributions
- Method : depending on W decay from $t \rightarrow bW$, search for
  - $W \rightarrow qq'$: 4 jet topology
  - $W \rightarrow l\,\nu$: 2 jets + isolated lepton
  - tag the b-jet
  - m_{top} dependence reduced by re-optimization
- Data : 189-207 GeV , 625 pb^{-1}



no significant excess observed

Impact of Higgs searches on LSP limit





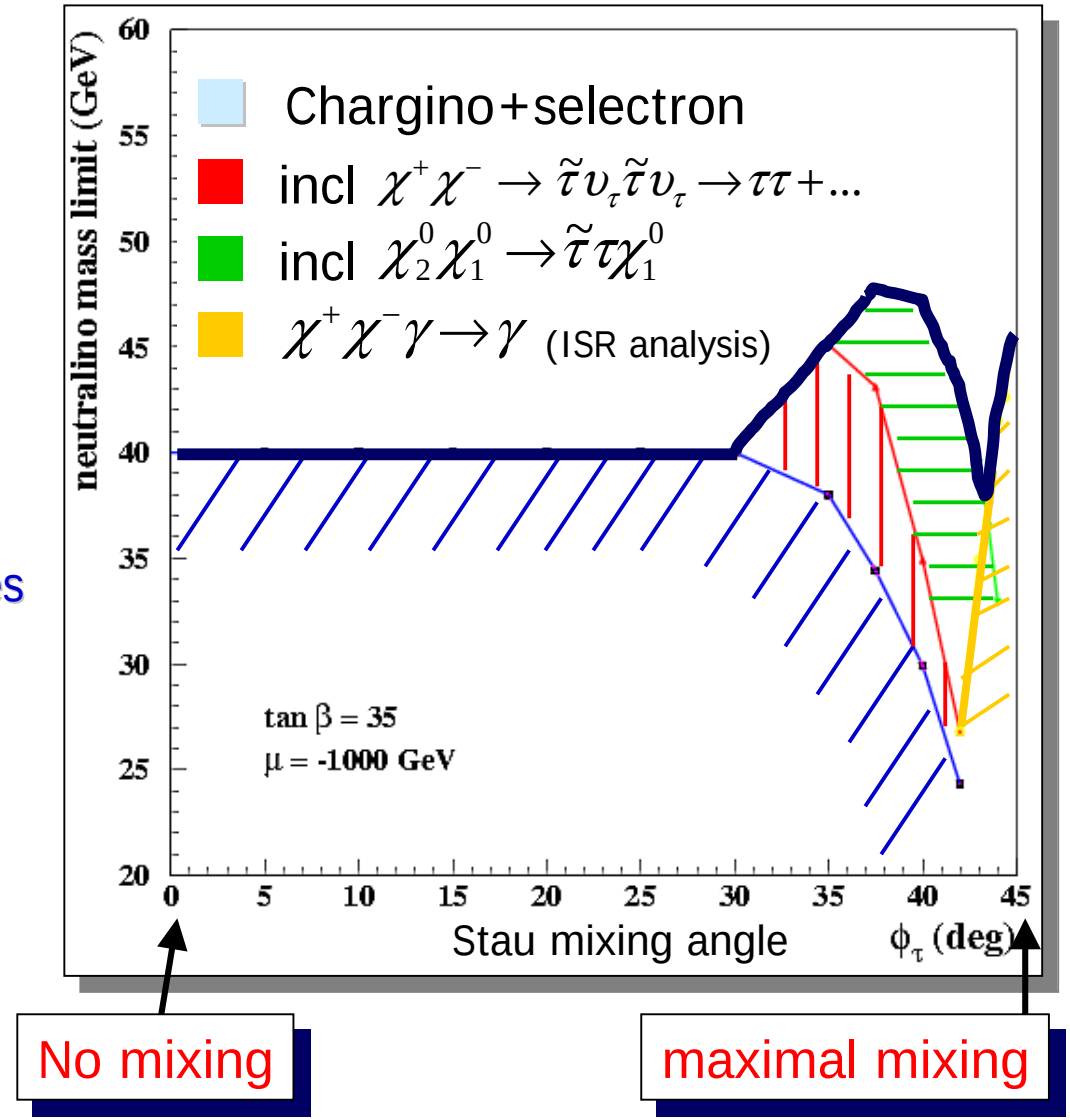
- Aim : study impact of Higgs searches on m(LSP) limit
- Method : radiative corr. to Higgs mass
  = f(log(m_{stop}/m_{top}), tanβ)
  - limit on m_h ⇒ limit on m_{stop} vs tanβ ⇒ limit on M_2 vs tanβ for fixed m_0 ⇒ improve limit m(LSP) vs tanβ
  - small m_0 ⇒ $m_{\tilde{\chi}^\pm} = m_{\tilde{\nu}}$ ⇒ no sensitivity (corridor)
    - but small m_0 ⇒ small slepton masses
- Data : take limits on $m_h < 113.5$ GeV/c^2 as well as MSSM scan

Impact of stau mixing on LSP limit

$$M_{\tilde{\tau}} = \begin{pmatrix} m^2_{\tilde{\tau},L} & m_\tau (A_\tau - \mu \tan\beta) \\ & m^2_{\tilde{\tau},R} \end{pmatrix}$$

$$\text{large mixing} \Rightarrow m_{\tilde{\tau},1} \quad \text{small}$$

- Aim : avoid drop in m(LSP) limit for large stau mixing
- Method :design dedicated searches for
  - tau final states
  - “invisible” final states
  - for large tanβ, deep gaugino region
- Data : 189 - 208 GeV



Status of the SM Higgs Search

- Results published in PLB 495 (2000) 1 : 3σ excess
  - 2 independent analysis streams. Analyses frozen before data taking!
- During last months following developments
  - Additional MC $\longrightarrow$ more precise shapes and efficiencies
  - all Y2K data reprocessed in December 2000 (gained $\approx 1 pb^{-1}$)
    - NOTE : 3 most significant candidates were already reprocessed before the publication, showing that they are stable
  - New LEP E_{CM} (about 140 MeV lower)
  - improved treatment of beam-induced background
    - studied on random triggers, “dirty MC” generated, cleaning procedure implemented
  - further systematic studies
    - evaluated impact of uncertainties from b-tagging, correlations in discriminating variables, jet smearing, gluon splitting, α_s, MC description of selection variables on $(1-CL_b)$

Status of the SM Higgs Search...

- Outcome :

The effects of recent changes and of systematic uncertainties are within 0.2 σ

as estimated in our publication

- We are very close to publishing our final paper on this topic...

Summary

- Plenty of (preliminary and final) physics results using data collected by ALEPH at LEP1 and LEP2.
- Extensive work put into the studies of systematic uncertainties of the SM Higgs search
  - result is stable. Final publication to come soon.
- For more details, have a look at

  http://alephwww.cern.ch/ALPUB/oldconf/summer01/summer.html